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AUTHOR Miller, Cynthia A.
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ABSTRACT

Research supports the premise that various mathematical topics can be categorized as being performed better by the left or right brain hemisphere. Hemispheric lateralization is defined as a learner's preferred hemisphere of control. Torrence's "Human Information Processing Survey" was given to 170 black female college students enrolled in Precalculus I (college algebra), Precalculus II (trigonometry, vectors, conics, and complex numbers), or Analysis I (beginning calculus for mathematics/science majors) to measure lateralization preference. Overall course grade was used to measure mathematical success/failure. Using a dichotomous left/right lateralization classification, descriptive statistics indicated that successful Precalculus I students were usually left dominant while unsuccessful students were usually right dominant. Successful Precalculus II students tended to be right dominant, while unsuccessful students were usually left dominant. No lateralization differences were observed in successful Analysis I students, but unsuccessful Analysis I students were more often left dominant. Two definitions of "success" yielded similar results. Included are 13 tables and 25 references. (DC)

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CAN HEMISPHERIC LATERALIZATION BE USED AS A PREDICTOR OF SUCCESS FOR BLACK WOMEN IN COLLEGE MATHEMATICS COURSES?

BY

CYNTHIA A. MILLER

ASSISTANT PROFESSOR

SPELMAN COLLEGE

MATHEMATICS DEPARTMENT

ATLANTA, GEORGIA 30314

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ABSTRACT

Torrance's Human Information Processing Survey (HIPS) was given to 170 Black female college students enrolled in Precalculus I (college algebra), Precalculus II (trigonometry, vectors, conics, and complex numbers), or Analysis I (beginning calculus for mathematics/science majors) to measure lateralization preference. Overall course grade was used to measure mathematical success/failure. Using a dichotomous left/right lateralization classification, descriptive statistics indicated that successful Precalculus I were usually left dominant while unsuccessful Precalculus students were usually right dominant. Successful Precalculus II tended to be right dominant, while unsuccessful students were usually left dominant. No lateralization differences were observed in successful Analysis I students, but unsuccessful Analysis I students were more often left dominant. Two definitions of "success" (coursegrade: A; or coursegrade: A or B) yielded similar results. It appears that for beginning calculus students, left brain skills are a necessary but not sufficient condition for success.

INTRODUCTION

Hemispheric lateralization is defined as a learner's preferred hemisphere of control.[1] In almost every task, electrical activity is present in both hemispheres of the brain. But even though both hemispheres are working on the same task, they work in different ways, with one dominant hemisphere being responsible for decision making. Various lateralization tests (verbal, figural, eye movement, dichotic listening, EEG, PET and CAT scans, magnetic resonance, et al), position a learner on a continuium: L + R Can a learner's position on the continuium predict success or failure in freshman level college mathematics courses?

A large body of research concurs that the left hemisphere is primarily responsible for written and spoken language, abstract symbolism, number operations, linear processing, rational decision making, and deductive logic. The right hemisphere is primarily responsible for spatial skills, pattern recognition, creativity, parallel processing, intuitive decision making, and inductive logic. Research supports the premise that various mathematical topics can be categorized as being performed better by the left or right hemisphere. Franco and Sperry worked with split brain patients (epileptic patients who have had the cable of nerve fibers which connects the two hemispheres severed), and

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[1] Zdenek, M. 1983

found that geometry is processed better by the right hemisphere while arithmetic operations appear to be processed better by the left hemisphere.[2] In another study, Sperry found the right hemisphere to "involve a direct apprehension and cognitive processing of spatial forms and spatial relations."[3] Gardner found that the left hemisphere has the ability to read and produce the symbols of mathematics while the right hemisphere understands numerical relations and concepts.[4] Davidson concurred that the right hemisphere is better at grasping the "big picture" while the left hemisphere is better at remembering the details of mathematics.[5]

RATIONALE FOR THE STUDY

This researcher has found no body of research which predicts success or failure in either a particular mathematics topic or in a particular mathematics course, based on a learner's hemispheric lateralization. If we could establish that certain topics such as graphing, solving equations, solving non-routine word problems, and proving theorems were done better by one type of brain dominant learner, then perhaps we could improve the mastery of these topics. Similarly, if we knew that a particular course such as algebra, trigonometry, calculus, or statistics had a

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[2] Franco, L. and R. W. Sperry 1977

[3] Sperry, R. W. 1972

[4] Gardner, H. 1983

[5] Davidson, P. 1984

higher success rate for left or right brain dominant learners, we could use this knowledge to our advantage as both educators and learners. Hence, the rationale for this study.

PURPOSE OF THE STUDY

This paper is a report of a research study conducted at Spelman College by myself with the cooperation of ten faculty members from the mathematics department.[6] The general purpose of the study was to investigate the relationship between a student's score on a standardized hemispheric lateralization test and their success or failure in the following mathematics courses: Precalculus I (algebra), Precalculus II (trigonometry, vectors, complex numbers, and conics), and Analysis I (beginning calculus for mathematics/science majors). Since established theories on this topic could not be located, it was anticipated that hypotheses would be generated for more rigorous study.

METHODOLOGY

Spelman College is a private, liberal arts college of approximately 1700 students. Founded in 1881, it is a historically Black college for women. Located in Atlanta, Georgia, Spelman is part of the Atlanta University Consortium of colleges. During the 1984-1985 academic year, which consisted of

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[6] I would like to acknowledge the cooperation of the following faculty members in the data collection of this study: Dr. Biggers, Mr. Cosnett, Dr. Ervine, Dr. Freiser, Dr. Glass, Dr. Jensen, Ms. Lowe, Mr. Onukwuli, Dr. Shah, and Dr. Smith. Special thanks to Dr. Shah for her statistical advice.

two semesters, an informal pilot study was performed on classes taught by the investigator. The results of the pilot study deemed that a formal study might produce significant results. During the 1985-1986 academic year, students in all sections of the following courses were given an opportunity to participate in this study: Precalculus I, Precalculus II, and Analysis I. The sample consisted of 170 students; 119 Precalculus I, 31 Precalculus II, and 20 Analysis I women students. Students were neither rewarded for participation, nor penalized for non-participation. None of these sections were taught by the investigator. Students were given Torrance's "Human Information Processing Survey" (HIPS)[7] hemispheric lateralization test at the end of the semester. They were given no other information about hemispheric lateralization. The HIPS instrument is a 40 item, multiple choice (a,b, or c), paper/pencil test which contains Left (L), Right (R), and Integrated (I) coded responses. An integrated response indicates no preference for a left or right brained strategy. It translates raw data scores into standard scores which are compared to percentiles of the general population of persons who have taken the survey. The distribution follows the Standard Normal Curve. A subject is categorized as being Left Dominant (L), Right Dominant (R), Integrated (I), or Mixed (M). In order to be classified as L, R, or I, the standard score in that category must be at least one

[7] Torrance, E. P.and B. Taggart and W. Taggart 1984

standard deviation above the mean. All other subjects (with approximately equal scores in the three areas) are designated as Mixed. An Integrated learner uses both left and right hemispheres in the same task. A Mixed learner uses a left or right brain strategy, depending on the situation. See Table 1 for the distribution by category:

HEMISPHERIC LATERALIZATION

	L	R	I	M	TOTALS
# Students	32	44	16	78	170
Percentages	19	26	9	46	100%

TABLE 1

Students who had withdrawn were contacted by mail or phone, and were invited to participate in the study. The final grades for each subject in the study were collected for analysis. Each professor had their own grading scheme, and no effort was made to standardize the grades. All sections of each course, for both semesters were pooled.

ANALYSIS OF DATA

Since this was the initial analysis on the data, only descriptive statistics have been reported in this paper. Once hypotheses have been formulated, more powerful inferential statistical methods will be applied.

Success (S1) was initially defined as attaining a grade of A, B, or C, while failure (F1) was defined as making a grade of

D, F, or withdrawal from the course. When the percentages of students succeeding or failing were examined against the four lateralization categories (L, R, I, and M), for the three courses, no trend emerged. Success (S2) was then redefined as making a grade of A or B, and failure (F2) was redefined as making a grade of F, or withdrawal. Tables comparing lateralization (L, R, I, M) with success (S2) and failure (F2) were prepared for each course. See Tables 2, 3, and 4.

HEMISPHERIC LATERALIZATION

	L	R	I	M	TOTALS
S2	29	21	14	36	100%
F2	14	44	0	42	100%

TABLE 2: PRECALCULUS I
PERCENTAGE DISTRIBUTION

Table 2 shows that the majority of the successful students in Precalculus I were categorized as Mixed, and the second most successful group was Left. Of the Precalculus I students who experienced failure, the largest group was classified as Right.

HEMISPHERIC LATERALIZATION

	L	R	I	M	TOTALS
S2	8	31	15	46	100%
F2	0	0	0	100	100%

TABLE 3: PRECALCULUS II
PERCENTAGE DISTRIBUTION

Table 3 indicates that the most successful Precalculus II students were classified as either Mixed or Right, while all of the students who experienced failure were Mixed.

HEMISPHERIC LATERALIZATION

	L	R	I	M	TOTALS
S2	20	0	0	80	100%
F2	30	0	10	60	100%

TABLE 4: ANALYSIS I
PERCENTAGE DISTRIBUTION

In Analysis I, mixed students accounted for the vast majority of both successes and failures, as indicated in Table 4.

Since a trend seemed to be emerging, success (S3) was redefined once more to be the attainment of a grade of A, but failure (F3) was still defined as a grade of F or withdrawal. These new percentages were examined for each course. See Tables 5, 6, and 7.

HEMISPHERIC LATERALIZATION

	L	R	I	M	TOTALS
S3	27	20	13	40	100%
F3	14	44	0	42	100%

TABLE 5: PRECALCULUS I
PERCENTAGE DISTRIBUTION

HEMISPHERIC LATERALIZATION

	L	R	I	M	TOTALS
S3	0	25	0	75	100%
F3	0	0	0	100	100%

TABLE 6: PRECALCULUS II
PERCENTAGE DISTRIBUTION

HEMISPHERIC LATERALIZATION

	L	R	I	M	TOTALS
S3	0	0	0	100	100%
F3	30	0	10	60	100%

TABLE 7: ANALYSIS I
PERCENTAGE DISTRIBUTION

Tables 5, 6, and 7 replicate the findings of Tables 2, 3, and 4 for all three courses. Left brain thinking seemed to be indicative of success in Precalculus I, while right brain thinking was associated with failure in Precalculus I. No similar pattern emerged for Precalculus II or Analysis I. In these two courses, the vast majority of both successful and unsuccessful students were Mixed. This is logical when we consider that 46% of the sample was classified as Mixed (See Table 1).

In order to focus on the Left/Right differences, it was decided to simplify the lateralization classification scheme to

only two categories: Left or Right. A subject's left and right standard scores were compared, with the highest score determining the category. Ties were discarded. The same three success/failure schemes were used for comparison:

S1 = A, B, or C S2 = A or B S3 = A
F1 = D, F, or W F2 = F or W F3 = F or W

Using the S1/F1 scheme produced very small differences in the three courses, and will not be reported.

Tables 8 - 13 display the lateralization percentages for each course using S2 and S3 success/failure schemes :

	LATERALIZATION		
	L	R	TOTALS
S2	59	41	100%
F2	42	58	100%

TABLE 8: PRECALCULUS I
PERCENTAGE DISTRIBUTION

	LATERALIZATION		
	L	R	TOTALS
S3	64	36	100%
F3	42	58	100%

TABLE 9: PRECALCULUS I
PERCENTAGE DISTRIBUTION

Tables 8 and 9 indicate that left brain learners were more successful than right brain learners in Precalculus I. The statement is even stronger when success was defined as making a grade of A instead of A or B. This seems logical when we consider the left brain algorithmic processes used to solve equations, evaluate functions, and to perform polynomial and radical operations.

	LATERALIZATION		
	L	R	TOTALS
S2	38	62	100%
F2	50	50	100%

TABLE 10: PRECALCULUS II
PERCENTAGE DISTRIBUTIION

	LATERALIZATION		
	L	R	TOTALS
S3	25	75	100%
F3	50	50	100%

TABLE 11: PRECALCULUS II
PERCENTAGE DISTRIBUTION

In Precalculus II, right brain learners were more successful than left brain learners in both success/failure schemes. Perhaps this can be explained by the spatial skills needed in trigonometry, vectors, complex numbers, and the conics.

	LATERALIZATION		
	L	R	TOTALS
S2	50	50	100%
F2	70	30	100%

TABLE 12: ANALYSIS I
PERCENTAGE DISTRIBUTION

	LATERALIZATION		
	L	R	TOTALS
S3	50	50	100%
F3	70	30	100%

TABLE 13: ANALYSIS I
PERCENTAGE DISTRIBUTION

In Analysis I, under both success/failure schemes, the unsuccessful students were more often left brain thinkers, but the successful students were evenly divided. Calculus seems to be an equal blend of left brain activities (algebra, differentiation, maximizing functions, et al), and right brain activities (graphing, 3-D drawing, pattern recognition, deriving equations and functions, et al). Although left brain skills are

certainly a prerequisite, right brain skills seem to be needed for the more advanced topics in calculus.

SUMMARY AND CONCLUSIONS

From the results of the descriptive analysis, one can form the following hypotheses for later testing:

1. Left brain thinkers outperform right brain thinkers in Precalculus I (algebra).

2. Right brain thinkers outperform left brain thinkers in Precalculus II (trigonometry, vectors, complex numbers, and conics).

3. Both types of thinking are required to be successful in Analysis I (beginning calculus for science majors).

It is a well established fact that men outperform women in the areas of mathematics, technology, and natural sciences.[8] Mathematics is a prerequisite for such subjects as computer science, engineering, physics, astronomy, and chemistry. Several lateralizational studies have found that women tend to be more left brained in their thinking, while men tend to be more right brained.[9] The hypotheses generated in this study support the premise that right brain strategies are necessary for higher mathematics. Many studies have described the importance of spatial visualization as a prerequisite for mathematics, science,

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[8] Fennema, E. and J. Sherman 1977

[9] Springer, S. and G. Deutsch 1981, Witelson, S. F. 1976, and R. Restak 1984

and engineering.[10] As our world becomes more technological, right brain thinking will become more important than ever. Therefore, it is of extreme importance that our mathematics education programs include a strong right hemispheric component. As mathematics educators, we should strive to maximize our students' learning experiences, regardless of their brain lateralization. Specific activities and exercises can be done to strengthen each hemisphere.[11] It is this researcher's personal experience that regular employment of these activities can lead to increased achievement in mathematics.

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[10] Guay, R. B. and E. D. McDaniel 1977, Battista, M. T. and H. W. Grayson and G. Talsma 1982, and Fennema, E. and J. Sherman 1977

[11] Buzan, T. 1974, Edwards, B. 1979, McGee-Cooper, A. 1982, Wonder and Donavan 1984

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